Draft

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MEMORANDUM FOR: Assistant for Plans and Development

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THROUGH : Chief, Development Branch

SUBJECT : [redacted] Image Enhancement Device (Contract 25X1A 25X1A [redacted] Task Order #1)

REFERENCE : [redacted] Proposal "Laser Optical Printer Program" dated 12 April 1963

25X1A 1. This memorandum discusses the subject Image Enhancement Device and a [redacted] proposal to study the characteristics of the device with a projectdd plan for improving the Enhancer's output by replacing its slow scan CRT display with a Laser output.

2. Image Enhancer - The original concept of the enhancer was to produce an item of equipment capable of performing a limited (three-level) power spectrum analysis of photographic imagery and of reconstituting the images in an enhanced form. The primary objective was to render small, low contrast targets more perceivable than in original transparencies. This was to be accomplished electronically by increasing the amplitude modulation of high frequencies and suppression of low frequencies contained in low contrast imagery.

3. Enhancer Output - It was initially planned to include two outputs. One was to be a TV Kinescope display for real-time viewing and to facilitate selective adjustment of the degree of enhancement. The second was to provide an exposed film output as a permanent record of considerably higher resolution and readability than the Kinescope display.

The plan to provide a TV Kinescope display was abandoned early in the program because the extremely slow input scan rate rendered this plan entirely infeasible, even for electrostatic storage tube applications. Several other

concepts for accomplishment of the original objectives were tried or at least studied. All failed to meet the requirements for one or more reasons and were abandoned.

4. Final Enhancer Design - In the final enhancer design a single output is produced as an extremely slow scan on a CRT. (Horizontal - 5 scans per second -- vertical - 1 scan per 12 minutes). This image scan is photographed with a Polaroid camera and requires twelve minutes to produce a complete photographic exposure. The system may be described as follows:

a. The optical system employs two light sources to provide two separate scanning spots. One is a 100 watt mercury vapor source, while the other is a 250 watt projection source. Their respective condenser optics image the light upon spot masks and through color filters to produce a small blue-green spot and a somewhat larger yellow spot. Both are required for scanning the image. Each of the spots is collimated. These two collimated and colored beams are mixed by a dichroic mirror. The single two-color beam is again collimated and then reflected from a rocking mirror which provides for deflection of the spot for scanning of the negative. The mirror oscillates about two perpendicular axes to provide the respective horizontal and vertical scans. The horizontal oscillation rate is 5 scans per second. The vertical oscillation rate is 1 scan in 12 minutes. After the two-color beam passes through the film it is collected by a lens and directed to a second dichroic mirror. This mirror re separates the two respective colored beams and transmits one and deflects the other. The two respective colored beams are again filtered and impinge on separate photomultiplier tubes.

b. At this point the light signals are converted to electrical signals. These signals are modulated in correspondence with the densities of the original transparency and electronically processed to display a

slow-scan raster designed to produce an enhanced putput picture.

5. Two-Spot Concept - As previously described, the image is scanned by two spots of differéng wavelength. One is of high frequency, blue-green in color, and has a spot size of 25_u. The second spot is of low frequency, yellow in color, with a spot size of 2500_u.

a. According to the concept described by the contractor, the small spot looks at a picture element of particular interest, while the large spot looks at surrounding picture elements. By electronic manipulation, the difference between the fine detail and its surroundings are made to constitute the enhanced electrical signals at the output. The signals obtained from the PMT's are split into three basic components; low, medium and high-frequency elements that can be separately manipulated. These are selectively varied in amplitude modulation by the operator, to achieve the degree of enhancement desired. The electronic circuit is designed to automatically increase the gain of high frequency signals and to reduce the gain of the low frequencies. Following separate amplification and individually controllable amplification channels, the three components are reconstituted to provide the final enhanced signal output. By these means it is said that high-frequency (Fine detail) information can be displayed at a higher contrast against its background, than in the original image.

6. Discussion:- The instrument discussed herein has proved to be an operational failure. This fact is generally agreed upon by all concerned, including the contractor and the design engineers. It can be said however, that a very great effort was made by the contractor, and even though this effort was not successful, the information gained should be quite useful in future related efforts.

a. Final images produced by Polaroid photography were badly degraded, of poor contrast and poor resolution. The reasons for the failure are too numerous to discuss fully. However, the more important reasons are enumerated below:

(1) No immediate access display was provided. Hence the operator had no way of knowing when the desired degree of enhancement had been achieved. This was unquestionably the most serious deficiency of all.

(2) The scan rate was too low. The time from start of scan to output display in print form was 13 minutes, even by Polaroid photography. The horizontal scan rate was 5 per sec. The vertical rate was one scan per 12 minutes. This time lag is prohibitive in a device of this type. The contractor was unable to devise a mechaniscal-optical scanning system capable of saanning at an acceptable rate.

(3) The instrument employed fifteen functional stages from the light sources to the output. Each contributed some loss in quality of the final output.

(4). The light sources were of insufficient intensity. It is known that image noise varies inversely by the square root of intensity. Since only small points of light were utilized it can be assumed that the deficiency of light intensity at the source substantially contributed to the output degradation.

(5). At the conception of the program very little was known about the parameters of image enhancement.

(6) The spot sizes were far too large for transfer of high frequency images. The small spot was 25 and the large spot 2500_u at the film stage. A 25_u spot could achieve a theoretical transfer of only 40 lpmm. This is assuming that no other losses occurred in the system. Such was far from true.

7. [redacted] Proposal - The referenced [redacted] proposal was submitted on the presumption that the proprietary [redacted] system of laser beam modulation and scanning could be adapted to the [redacted] Enhancer as a successful output stage.

a. Their proposal is excellent and describes features of laser frequency modulation and scanning that appear quite feasible and well worth exploiting.

b. The [redacted] proposed frequency modulation method makes use of two Piezoelectric transducers. Each consists of two crystals bonded together and used as a mirror mount. They possess a property whereby an impressed voltage across the crystal will cause it to expand or contract depending upon the polarity of the signal impressed upon it. When driven by modulated electrical signals from suitable inputs these produce motion of their respective mirror surfaces. By this means, modulated electrical signals from two transducers are converted to modulated light beams. These two surfaces when reflecting a single laser beam would produce a modulation of that beam corresponding to density variations in the original negative, profided the original scanner performed a faithful scanning function.

c. The [redacted] proposed method for final scanning makes use of a Bimorph Piezoelectric crystal that possesses the unique capability of deflecting light beams in X and Y directions when driven by electrical signals from a suitable source.

d. The [redacted] Proposal was based on an assumption that the [redacted] Enhancer produces a high quality modulated electrical input. It was further assumed that the enhancer (input signal) could be used to drive the Piezolectric crystals, which would in turn modulate the output light beam for producing a final photographic print. Such is not exactly the case however.

e. The prime function of the enhancer is to produce not merely an output print but an output print that has been enhanced. That is, a print that had its information characteristics changed to render it more readable than in a normal form. For this reason the input of the enhancer should be considered as those signals produced by the enhancer after they have been electronically manipulated (enhanced). Since the signals described above are near the output stage they contain several generations of degradation discussed earlier herein. Therefore, any high quality laser output stage making use of these signals would only reconstitute an image with all the degradations of the parent system.

f. The input from the enhancer could be taken directly from the two photomultiplier tubes. If this were the case, the signals would be prohibitively degraded for reasons previously stated and would carry the added disadvantage of requiring [redacted] to provide the enhancement stage. In other words, it appears conclusive that there is no point in the present enhancer from which high quality input signals could be taken.

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g. Perhaps the most important drawback in the program is brought about by the prhibitively slow scan rate of the [redacted] enhancer. The scan rate of the output laser can be no faster than the input of the enhancer. In fact it must be precisely synchronized with it. For this reason, even if the signals from the enhancer suffered zero loss, the system would be of little or no value without also providing an immediate readout. Otherwise, the operator would have no way of selecting the proper degree of enhancement and would see the result only after a 13 minute wait, just as in the present enhancer.

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h. In view of the limitations of the [redacted] Enhancer which have been enumerated [redacted], it seems that the [redacted] proposal is a bit too presumptuous. This of course was brought about by the lack of information

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concerning its characteristics. Furthermore, the title "Laser Optical Printer Program" may lead one to believe it is in competition with the [redacted] "Coherent Light Enlarger" Program", even though such is not the case.

8. The foregoing notwithstanding, [redacted]. does have superior capabilities in laser applications and has proposed unique modulation and scanning principles of marked potential. These should be exploited to the fullest. However, to avoid possible future disappointments, any program that involves possible additional development of the [redacted]. Enhancer should be undertaken on a realistic basis and not on the illusion that a usable instrument would result by mere replacement of its output stage.

a. Therefore, the [redacted] proposal should be reoriented to more nearly reflect its research nature. The initial phase of the program should be strongly directed toward ways in which lasers can be applied to image enhancement, and should give due recognition to the risks involved as well as possible alteratives.

b. There is no doubt that the enhancer developed by the [redacted] would be of value in the proposed [redacted] program and should be made available to them. In addition, the on-call servides of a [redacted] design engineer should be made available during the initial stages of the program.

9. Conclusions: It is concluded that:

a. The successful coupling of a laser output stage to the [redacted] Enhancer is very questionable.

b. The enhancer device and the knowledge gained in its development would be very helpful to [redacted] in their proposed program and should be made available to them along with the limited services of a design engineer.

c. The title of the proposed program should be changed to more accurately describe the program.

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d. A laser enhancement research program similar to that proposed by [redacted] would be in consonance with present and future photographic exploitation objectives and should be pursued.

10. RECOMMENDATIONS - It is recommended that:

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a. A laser enhancement research program be awarded to the [redacted], but that their proposal of 12 April 1963 be reoriented to more accurately describe the objectives.

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b. The existing [redacted] Enhancer be shipped to the [redacted] plant for any use that can be made of it.

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c. A simultaneous contract be awarded to the [redacted] for the on-call services of a design engineer during the initial stage of the program.